Pyroprocessing Plans for Spent Fuel Treatment and Waste Form Testing

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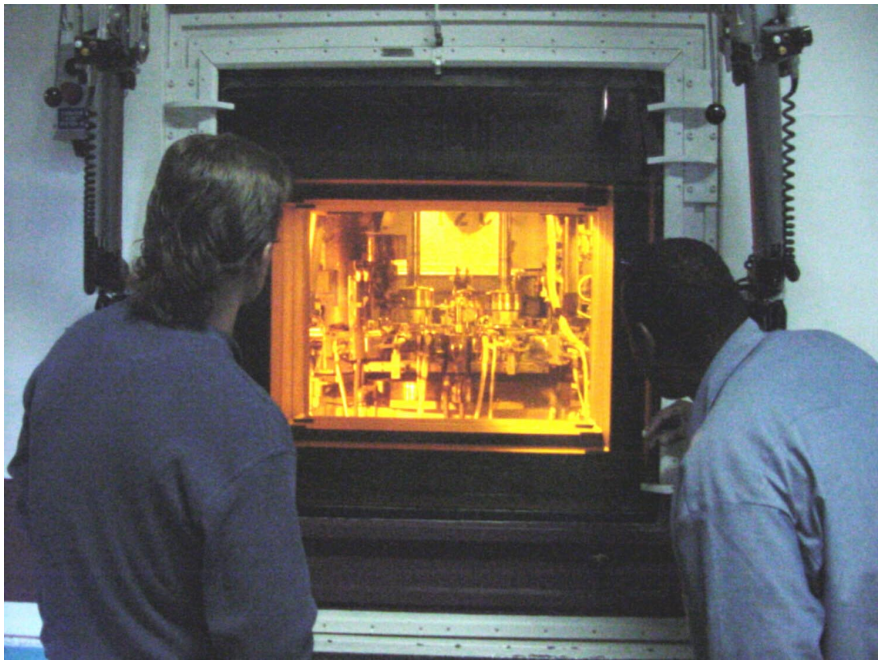
Changes for Spent Fuel Treatment Program

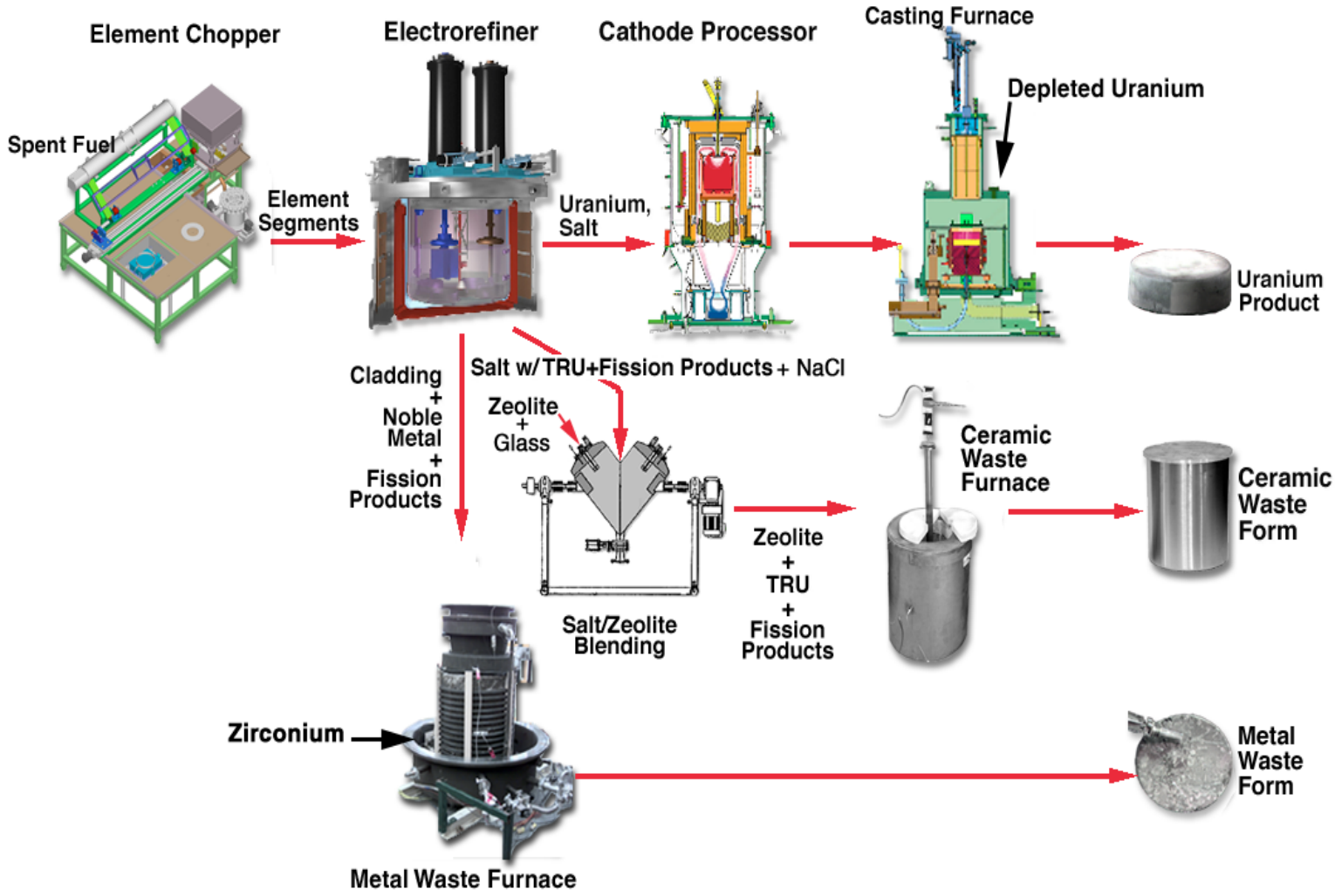
- **Since completing the EBR-II Spent Fuel Treatment (SFT) Demonstration Program in FY99, activities have been focused on treating the sodium-bonded spent fuel in an economic manner.**
- **Accomplishing this task required a focus on annual fuel treatment rate.**
- **An emphasis on technology activities was also required to:**
  - Increase process throughput
  - Complete scale-up of high-level waste production processes
  - Complete qualification of high-level wastes.

Changes for Spent Fuel Treatment Program (continued)

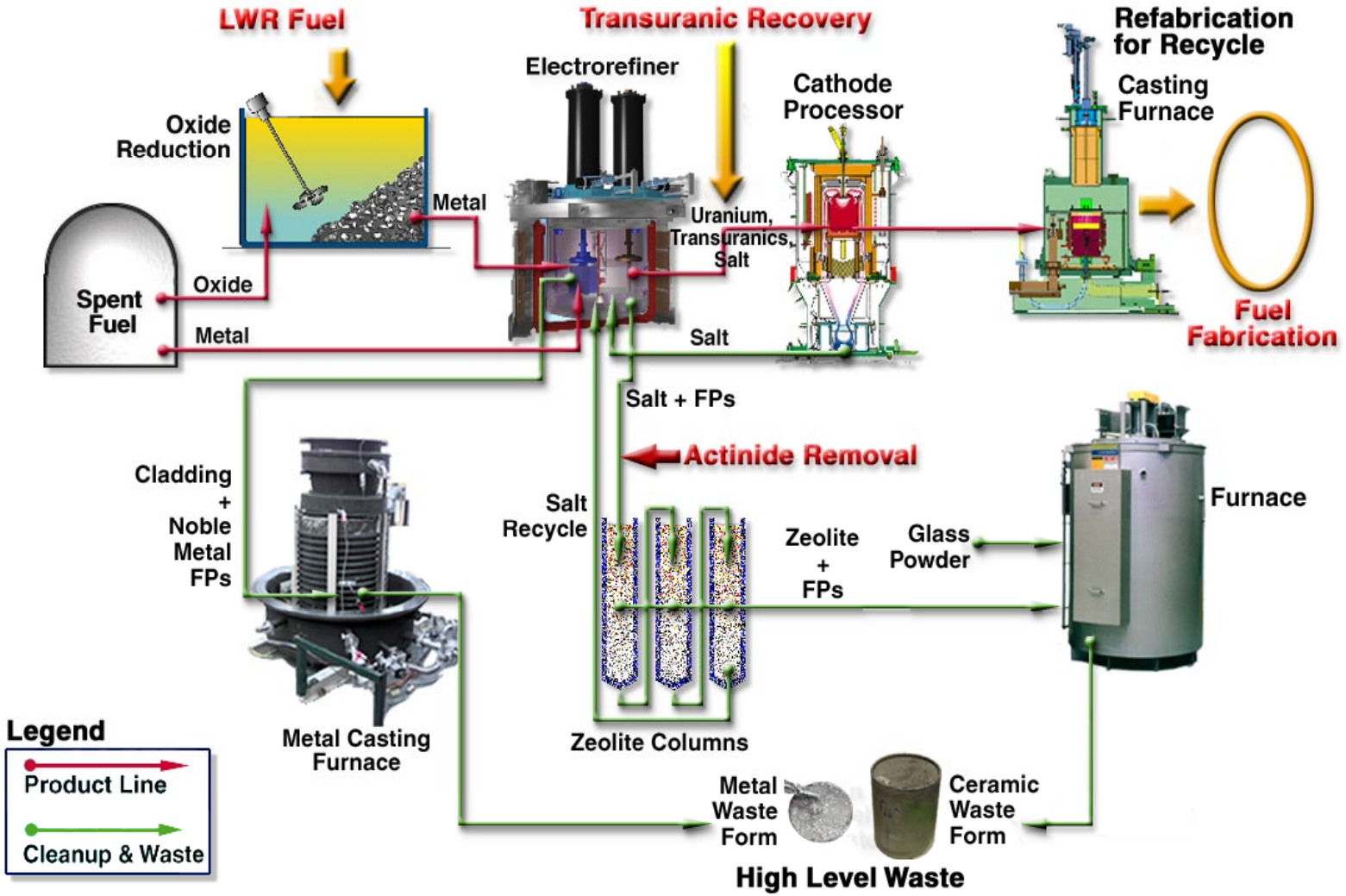
- **Focus of the program was directed by the need to meet the environmental commitments of DOE to the State of Idaho.**
- **Focus of the program is now to complete the development of advanced recycle technologies to support a deployment decision in FY07.**
- **Activities of the SFT Program support this goal, but addition technology gaps are now a major focus.**



Flowsheet for EBR-II Fuel Treatment

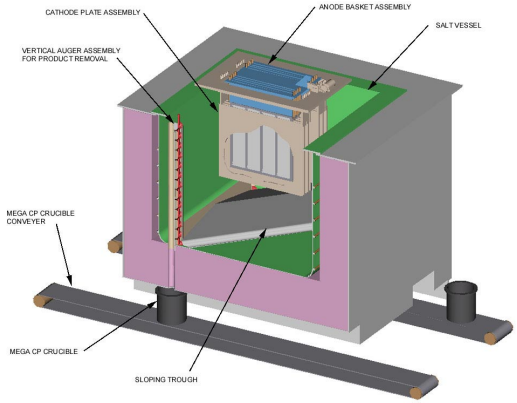


Pyroprocess Demonstration Gaps



New Activities in SFT Program

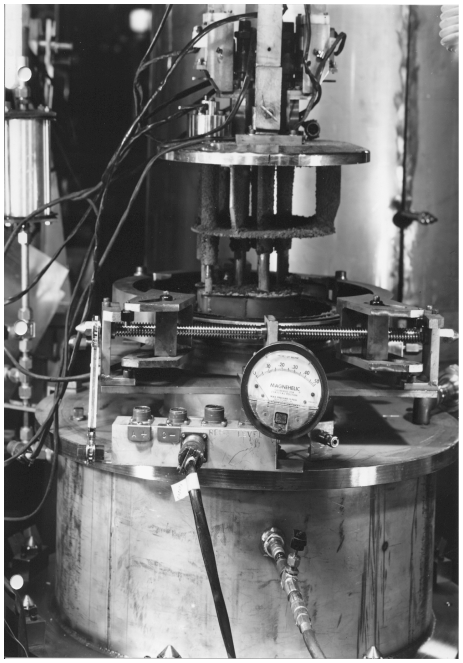
- **All activities previously covered under SFT are still included, but some are deferred to accommodate expanded scope.**
- **Expanded scope includes:**
  - Demonstrations of oxide reduction
  - Transuranic recovery
  - Advanced high-throughput electrorefiners
  - Development and demonstration of aqueous-pyro hybrid recycle flowsheets

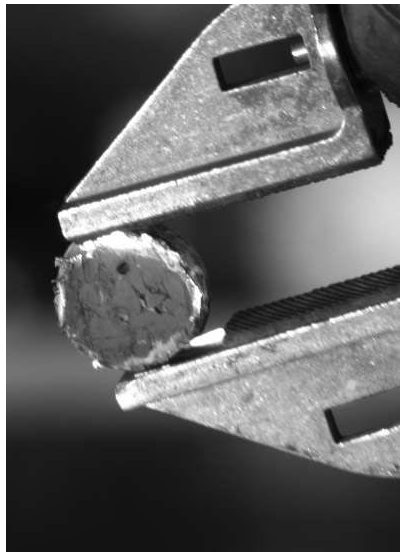


100 METRIC TON ER CONCEPT

Demonstration of Laboratory-Scale Reduction of Spent Oxide Fuel

- The Hot Fuel Dissolution Apparatus (HFDA) in the Hot Fuel Examination Facility (HFEF) is being readied to demonstrate reduction of oxide fuel.
- HFDA is being modified to more closely match electrode configurations being tested in at ANL in Illinois.
- Fuel from the BR-3 reactor stored at ANL will be used for the tests.
- Hot reductions should start by July 2003.



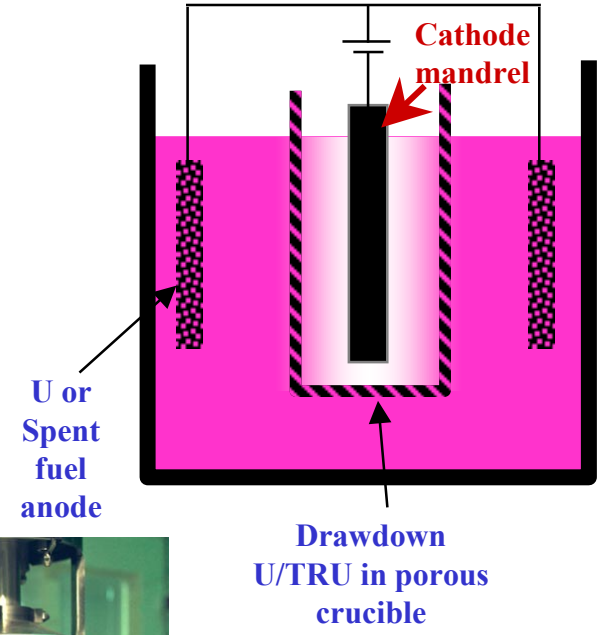


Engineering-Scale Oxide Reduction

- **Conceptual Design Development in FY03**
  - Evaluate process scale-up to a 20 – 100 kg batch size
  - Investigate compatibility and interface requirements between reduction system and Mark V electrorefiner
  - Assess hot cell work station availability
  - Define system design criteria
- **Implementation Plan Development in FY03**
  - Evaluate environmental issues (incl. NEPA)
  - Investigate facility safety matters
  - Identify criticality safety concerns
  - Outline transportation plans for acquiring spent LWR fuel
- **Demonstration in FY05**

Recovery of Transuranics

- Advanced transuranic recovery techniques are being developed in parallel with demonstration of existing equipment that was developed earlier.
- Advanced concepts include electrolysis.
- Reaction is $(U/TRU)Cl_3 \rightarrow U/TRU_{metal} + Cl_{2\ (gas)}$.
- Testing of existing equipment in early FY04 will support demonstrations of advanced technologies in later years.



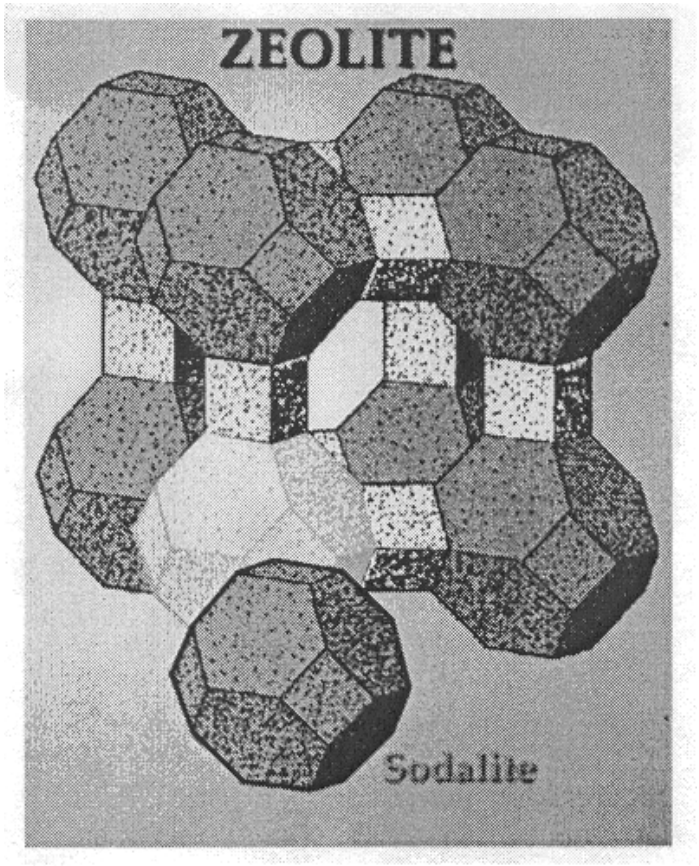
Waste Form Development and Testing

- Under the Spent Fuel Treatment Program the focus of waste testing was on production and qualification of waste forms for repository disposal.
- Waste forms are engineered for the pyroprocess.
- Process and waste form qualification are at an advanced stage.
- Under the focus of the previous program the waste forms being qualified for disposal still contain the transuranics and all fission products.

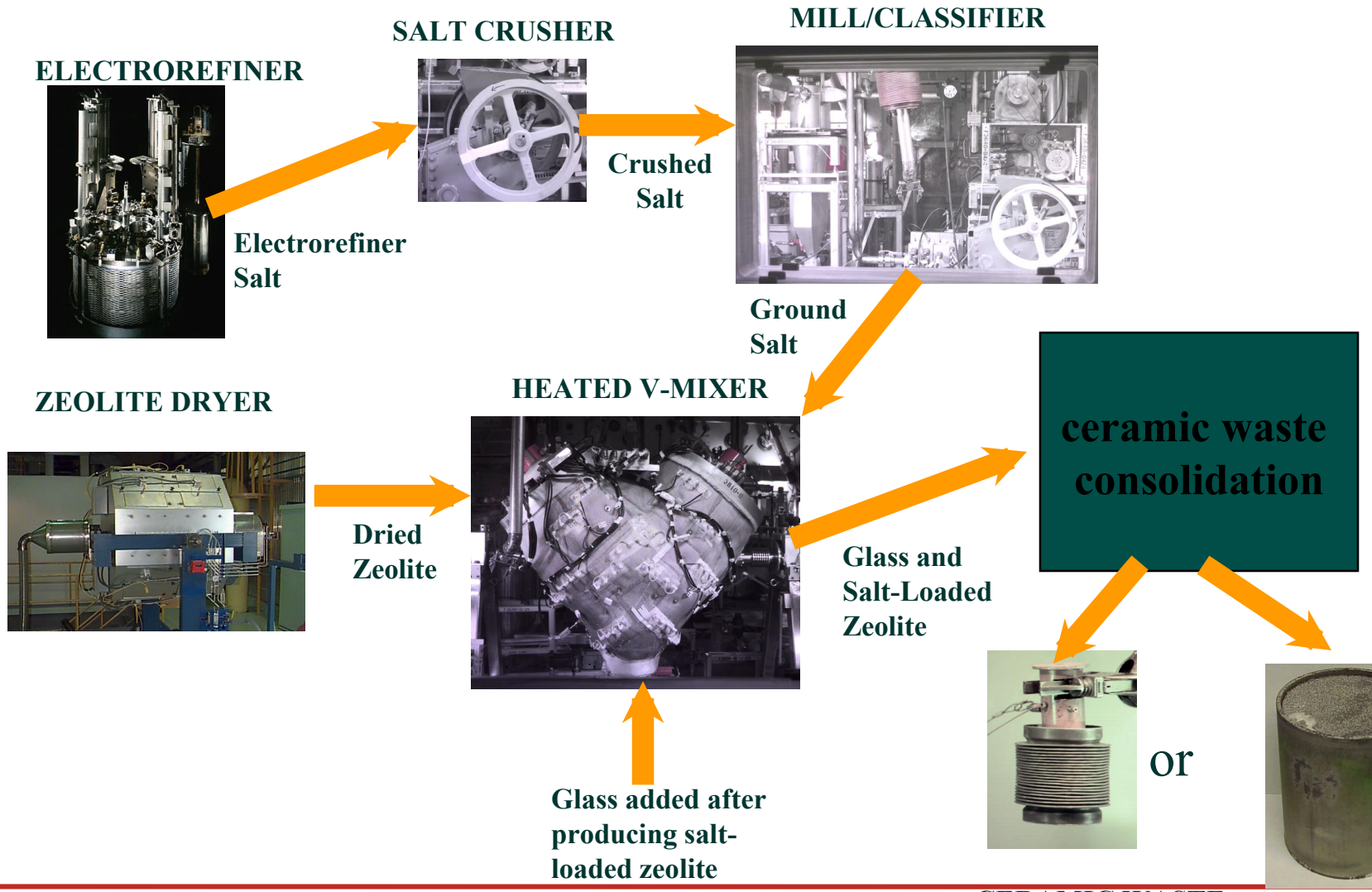
Ceramic Waste

- **The ceramic waste form is a zeolite-based, glass-bonded ceramic.**
  - Zeolites have cages in which salt molecules can be occluded.
  - Cations are available for ion exchange with fission products.
- **The electrorefiner salts containing the active metal fission products (alkali, alkaline earth, and rare earth) and transuranics are loaded into zeolite A.**
- **The salt loaded zeolite A converts to sodalite when processed at 800 - 925°C.**

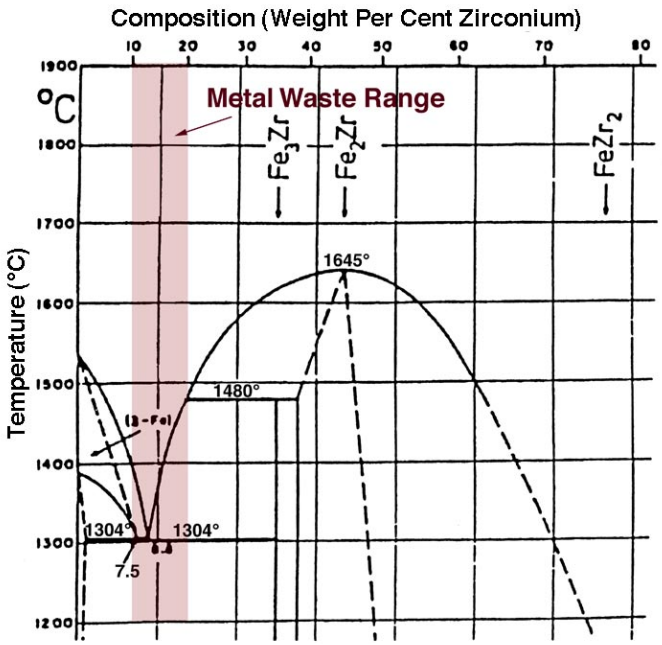
Unit Cell of Zeolite A :
$Na_{12}[(AlO_2)_{12}(SiO_2)_{12}]$



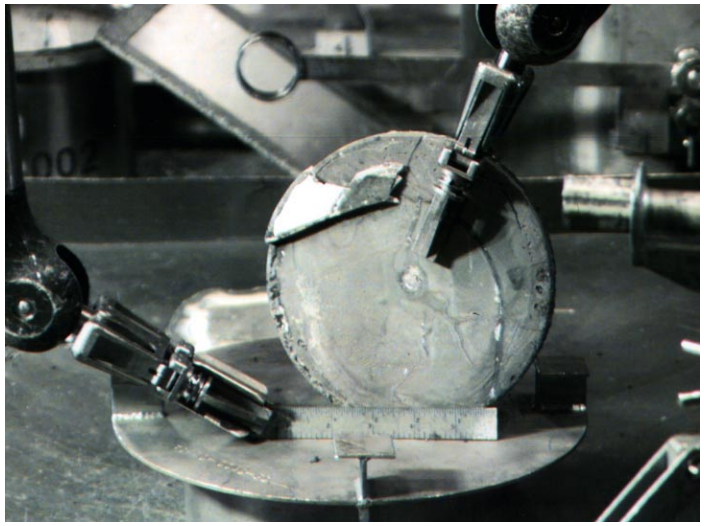
Ceramic Waste Process



Fe-Zr Phase Diagram for Metal Waste



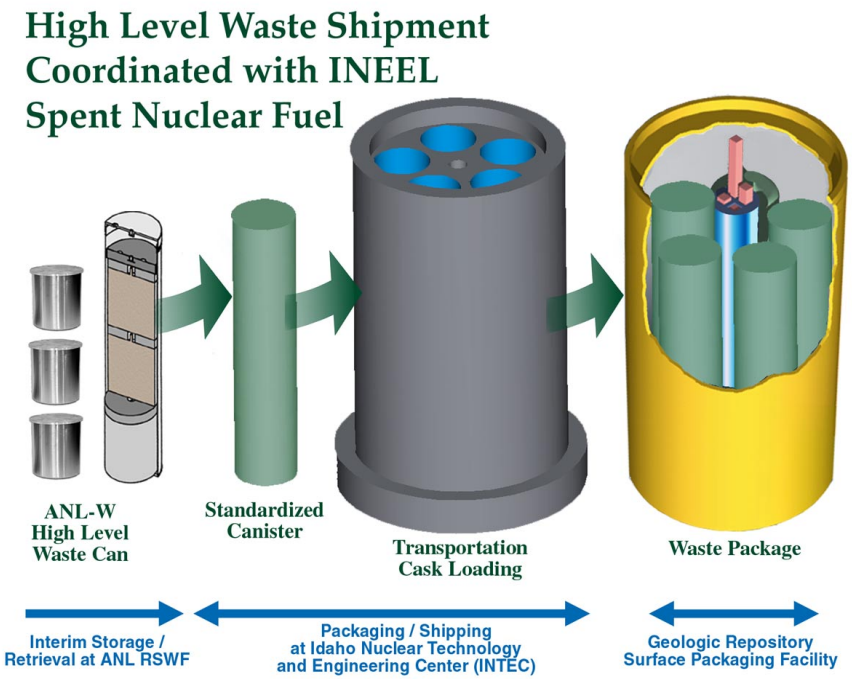
Cladding Hulls are Cast into Stainless Steel Zirconium Waste Form



Waste Form Qualification

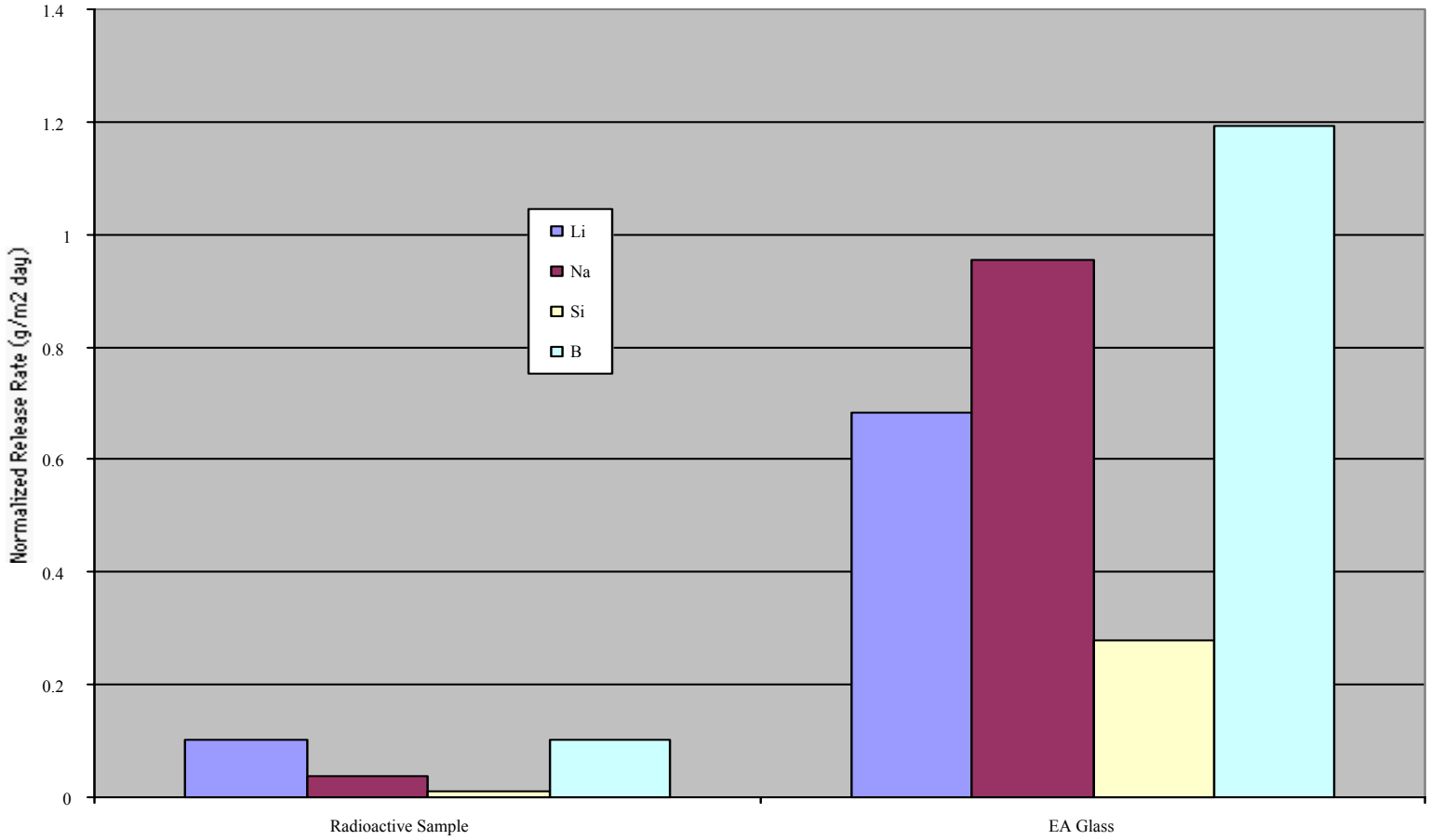
- **Waste forms are being extensively characterized for qualification.**
- **Waste form degradation models are being developed for each waste form.**
- **ANL is performing repository performance assessment calculations to assess the impact of the waste forms on the repository.**

Waste Qualification Interactions



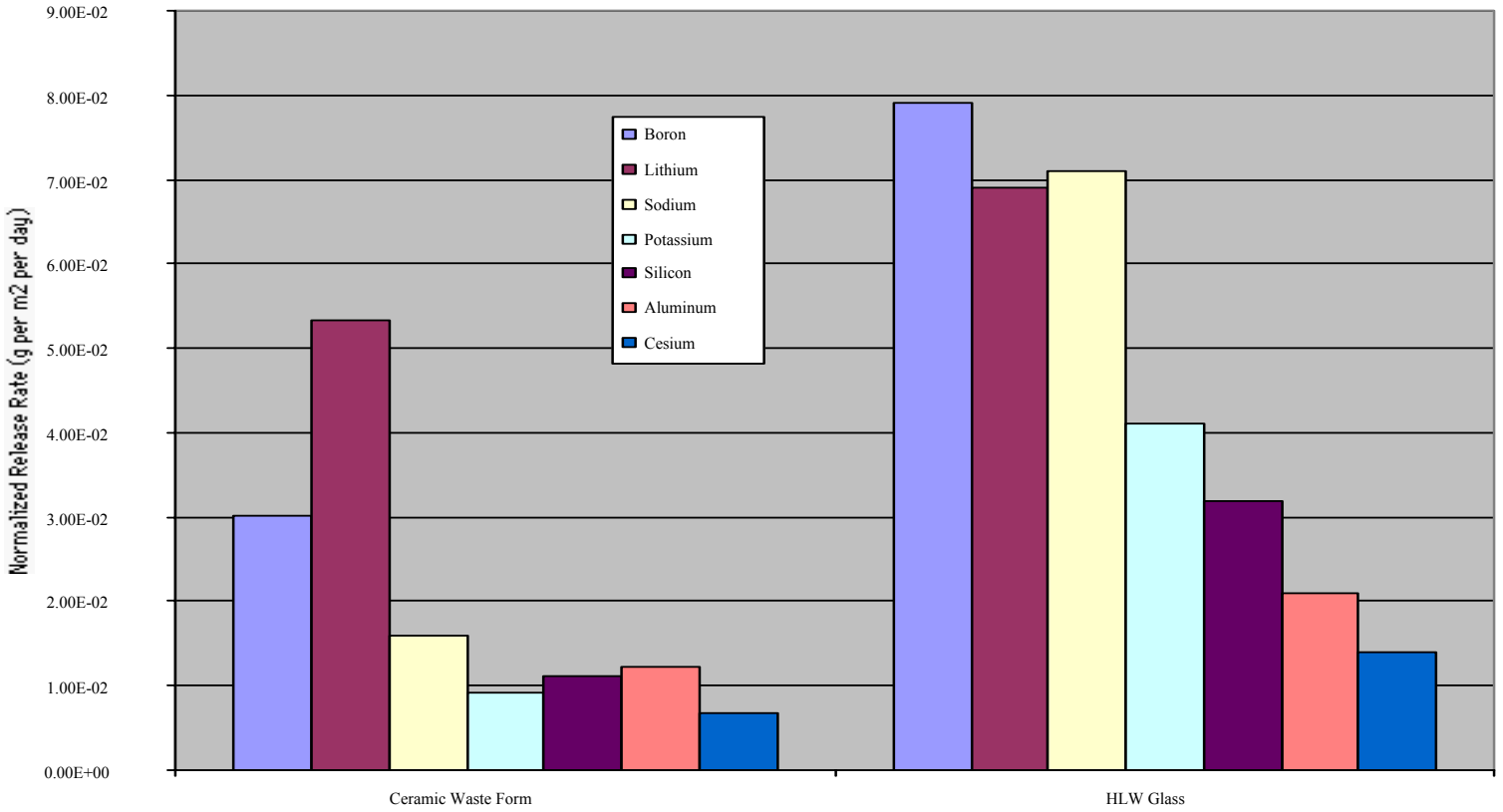
- **ANL is working within the high-level waste community to gain acceptance of the waste forms.**
- **Report prepared for Congress addressing the disposal of the waste forms.**
  - DOE-NE, DOE-RW (Office of Civilian and Radioactive Waste Management), and DOE-EM (Environmental Management) concurred on disposal plans.
- **ANL waste forms are now classified formally as high-level wastes in DOE orders.**

Radioactive Ceramic Waste Sample Versus HLW Standard



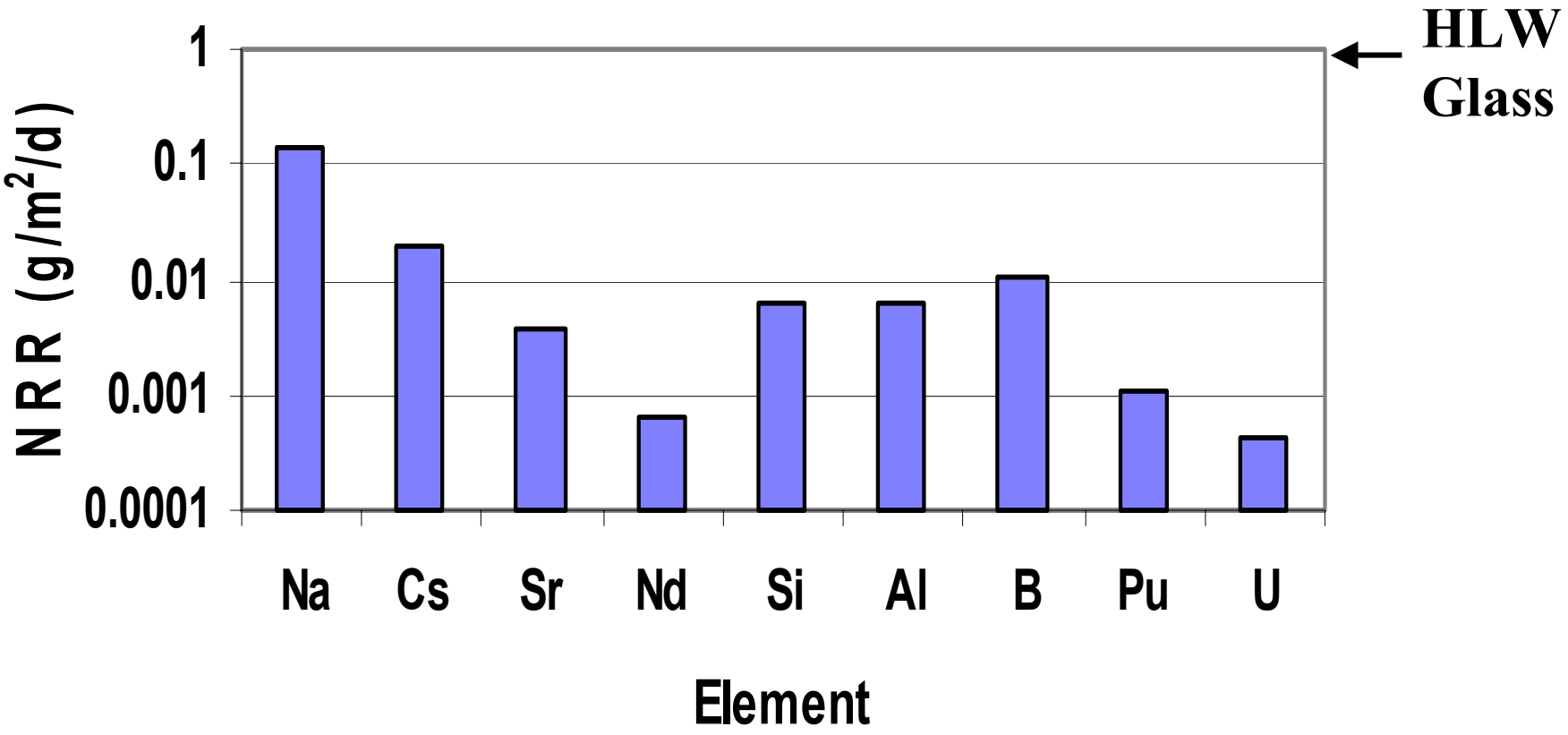
Product Consistency Test (PCT) Results

Comparison of Ceramic Waste Versus HLW Glass

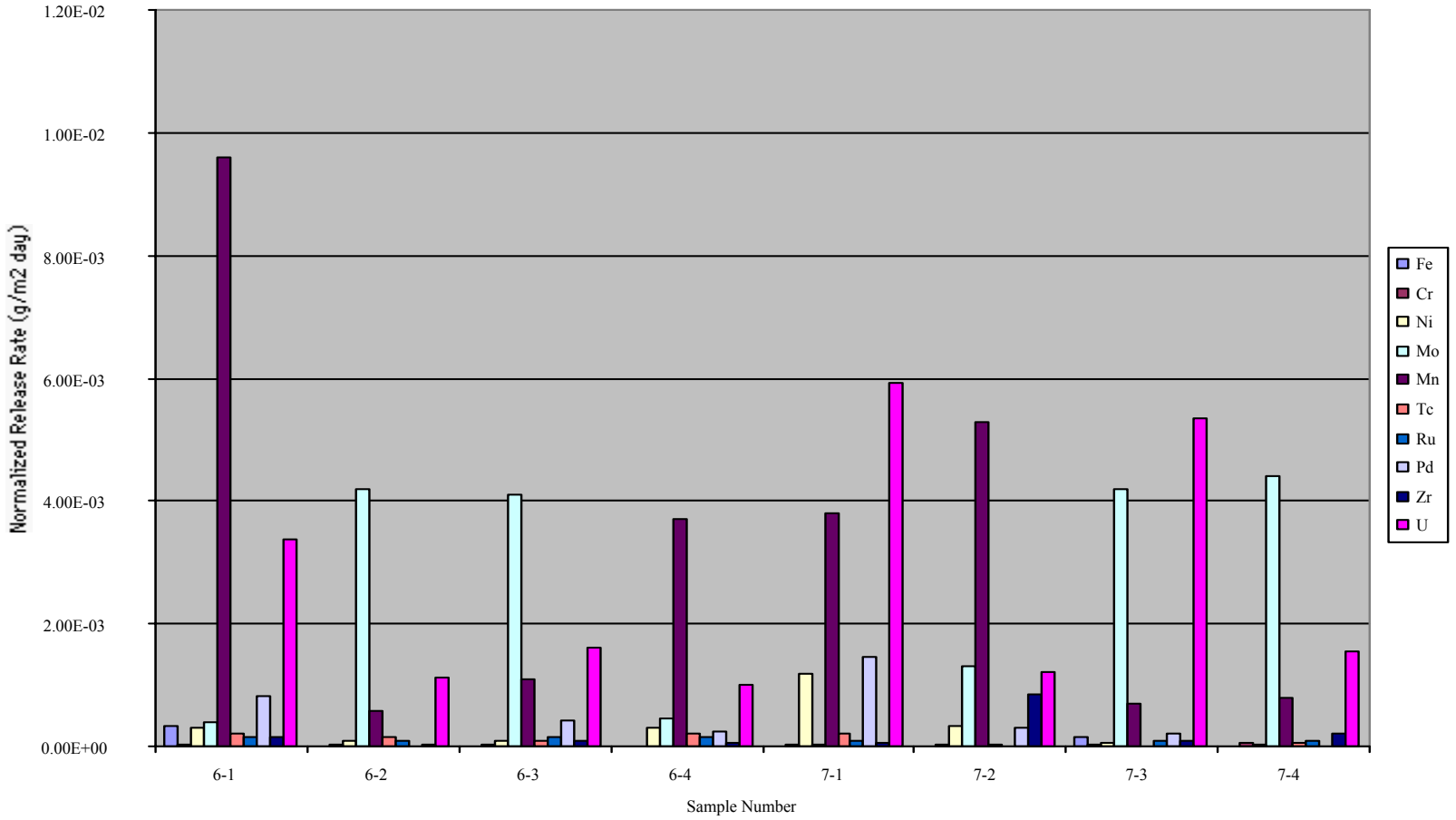


Product Consistency Test (PCT) Results

Elemental Normalized Release Rate for the Ceramic Waste



Immersion Test Results for Metal Waste Form Orders of Magnitude Better than Standard



Summary

- Spent Fuel Treatment Program is focused on demonstrating technology gaps for the pyroprocess.
- Sodium-bonded fuel will continue to be treated to support these demonstrations.
- Waste qualification activities are at an advanced stage.
- Waste forms are being qualified for disposal of troublesome elements like technetium and cesium.